The effect of oral caffeine intake on the perceived wakefulness in individuals with and without ADHD

Scientific Writing Exercise

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Summary

The paradoxon that caffeine has no effect or even decreases wakefulness is commonly described by Attention Deficit Hyperactivity Disorder (ADHD) patients as well as some healthy individuals. Paradoxical effects of caffeine in disorders of the dopaminergic / noradrenergic systems, like ADHD, may hint at non-stimulatory interactions of caffeine in these systems or adjacent neuronal pathways. We found a statistically significant difference in the effect of caffeine intake on the perceived wakefulness of ADHD patients and healthy individuals using a double-blind placebo-controlled trial, showing no mean increase in perceived wakefulness for ADHD patients. These findings lay the ground work for molecular investigations into the interactions of caffeine and the dopaminergic / noradrenergic systems, especially in disorders involving these neuronal pathways, and may even contribute to further our understanding of the biochemical basis of these disorders on a neurological level.

Introduction

ADHD is one of the most widespread neurodevelopmental disorders worldwide. (Abdelnour et al., 2022-09/2022-10) The current hypothesis for the neurobiochemical basis of ADHD is a disregulation of the dopamine / noradrenalin levels in certain brain regions like the prefrontal cortex, leading to executive dysfunction and other associated symptoms. (Purper-Ouakil et al., 2011) This is where the

first-line treatment option of stimulant medication takes effect by increasing the levels of the affected neurotransmitters to physiological normal levels. (Mechler et al., 2022)

Caffeine is the most widely consumed psychoactive drug worldwide and belongs, just like most ADHD medication, to the category of stimulants. (Ferré, 2013) This leads to many ADHD patients as well as individuals with undiagnosed ADHD to self-medicate with caffeine, as it has an overlapping effect spectrum with commonly prescribed ADHD medication. (Ágoston et al., 2022)

Paradoxically many ADHD patients (some healthy individuals as well) experience no increased wakefulness or even a tiring effect of caffeine. ("Why Does Coffee Make You Tired?" 2021) One proposed hypothesis for this paradoxical effect is that the stimulating effect of caffeine decreases the neurotransmitter imbalance present in ADHD patients, decreasing self-stimulating behaviour like racing thoughts or hyperactivity, promoting calmness and as a result tiredness. (Consulting, 2023)

However besides hypotheses, the paradoxical effects of caffeine in individuals with ADHD remain poorly understood and could not be proven until now. Here we show, using a randomized double-blind placebo-controlled trial, that ADHD patients do not show statistically significant increased alertness from caffeine consumption, while healthy individuals do. These findings will help understand

the neurobiochemical basis of ADHD and further our understanding on why and how stimulant medication can be used to alleviate ADHD symptoms.

Methods

Results

To investigate a possible correlation between the neurobiochemistry of ADHD and the effect of caffeine on perceived wakefulness, we recruited twelve healthy individuals and twelve individuals diagnosed with ADHD. Both groups were equally split into a group that was administered 30 mg of caffeine in the form of coffee and a group that was given the same amount of decaffeinated coffee, minimizing the possible effects of other compounds on our measured parameter.

Our measurements revealed a significant correlation between caffeine intake and perceived wakefulness in healthy individuals (average increase of 30%, $p = 0.005$) while not showing any significant differences for the group of ADHD patients (no increase / decrease, $p = 0.81$) as shown in Figure 1. This has also been corroborated by previous studies. (Leon, 2000)

In summary, we found that neurotypical individuals display a significant stimulatory response to oral caffeine consumption while individuals with ADHD did not show signs of increased wakefulness after intake of 30 mg of caffeine.

Discussion

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Declaration of Interests

The authors declare no competing interests.

Author Contributions

Conceptualization, T.N.; Methodology, T.N.; Formal Analysis, T.N.; Investigation, T.N.; Writing – Original Draft, T.N.; Writing – Review & Editing, T.N.; Project Administration, T.N.; Funding Acquisition, T.N.

Figures

References

Abdelnour, E., Jansen, M.O., Gold, J.A., 2022-09/2022-10. ADHD Diagnostic Trends: Increased Recognition or Overdiagnosis? Missouri Medicine 119, 467.

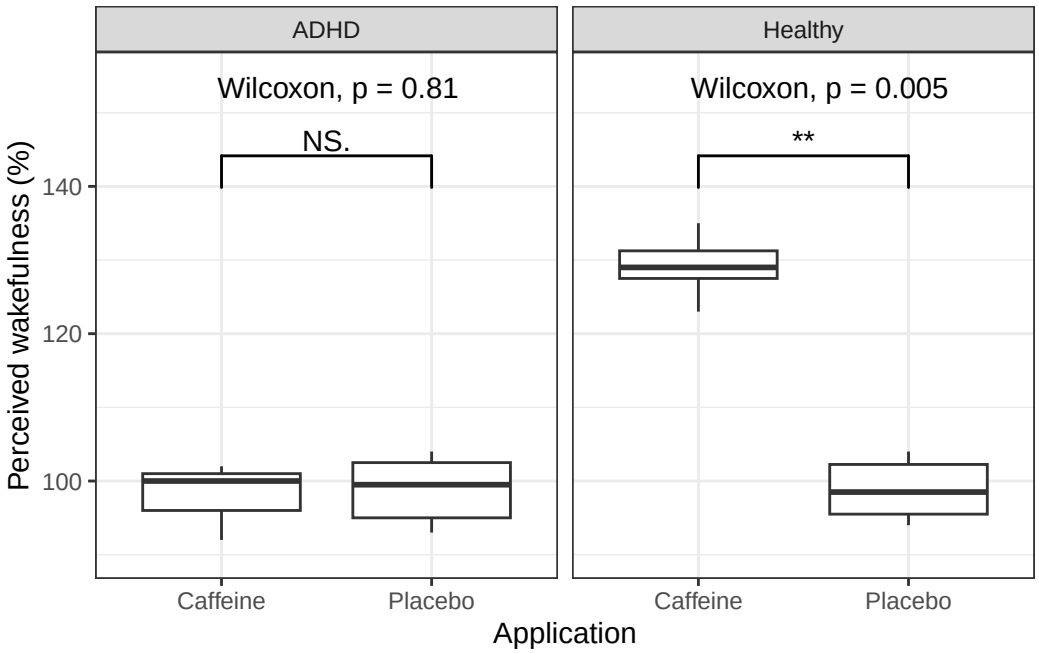

Figure 1: Effect of oral caffeine intake on the perceived wakefulness of healthy individuals and ADHD patients. Caffeine group was administered 30 mg of caffeine in form of coffee. Placebo group was administered decaffeinated coffee. 100% perceived wakefulness corresponds to normal wake alertness. Twelve individuals in each health status group. Six individuals per application. NS. = Not significant (P > 0.05); ** = Significant (P <= 0.01)

Ágoston, C., Urbán, R., Horváth, Z., van den Brink, W., Demetrovics, Z., 2022. Self-Medication of ADHD Symptoms: Does Caffeine Have a Role? Frontiers in Psychiatry 13. https://doi.org/10.3389/fpsyt.2022.813545

Consulting, E.E., 2023. Why Does Coffee Make Me Sleepy: ADHD & Caffeine. Effective Effort Consulting.

Ferré, S., 2013. Caffeine and Substance Use Disorders. Journal of Caffeine Research 3, 57–58. https://doi.org/10.1089/jcr.2013.0015

Leon, M.R., 2000. Effects of caffeine on cognitive, psychomotor, and affective performance of children with Attention-Deficit/Hyperactivity Disorder. Journal of Attention Disorders 4, 27–47. https://doi.org/10.1177/108705470000400103

Mechler, K., Banaschewski, T., Hohmann, S., Häge, A., 2022. Evidence-based pharmacological treatment options for ADHD in children and adolescents. Pharmacology & Therapeutics 230, 107940. https://doi.org/10.1016/j.pharmthera.2021.107940

Purper-Ouakil, D., Ramoz, N., Lepagnol-Bestel, A.-M., Gorwood, P., Simonneau, M., 2011. Neurobiology of Attention Deficit/Hyperactivity Disorder. Pediatric Research 69, 69–76. https://doi.org/10.1203/PDR.0b013e318212b40f

Why Does Coffee Make You Tired?, 2021. Sleep Foundation.